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**Incentives for Pollution
Control: Regulation or
(and?) Information**

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Incentives for Pollution Control: Regulation or (and?) Information^{*}

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Résumé / Abstract

De plus en plus de décideurs publics dans le domaine de l'environnement ont adopté des politiques de diffusion de l'information pour créer des incitations à une meilleure performance environnementale. Dans cette étude, nous examinons l'impact d'une liste noire de pollueurs publiée à tous les six mois, depuis 1990, par le Ministère de l'environnement en Colombie-Britannique qui, parallèlement à cela, poursuit une stratégie traditionnelle de contrôle et de mise en application de la réglementation. Les recherches précédentes ont examiné de façon isolée l'impact des mesures traditionnelles de réglementation et l'impact des programmes d'information, alors que nous proposons d'étudier simultanément les effets de ces deux types de mesures. Ce faisant, nous pourrions avoir une idée de l'impact « relatif » des mesures traditionnelles et émergentes. Nos résultats suggèrent que la liste des pollueurs de Colombie-Britannique a eu un impact plus important que les poursuites et les amendes traditionnellement émises par les autorités gouvernementales. Nos résultats montrent également que l'adoption de normes environnementales plus strictes a eu un effet important sur la performance environnementale des usines étudiées.

An increasing number of regulators have adopted public disclosure programs to create incentives for pollution control. In this paper, we study the impact of British Columbia's list of polluters whereby the province's environmental regulator reveals the name of plants which are either not complying with the regulation or are of concern to the regulator. Simultaneously however, the regulator continues to undertake legal action for those violating the regulation. Previous analyses have focused on studying either the impact of the traditional monitoring and enforcement practices or the impact of information programs. In this paper, we perform an empirical analysis of the impact of both traditional enforcement and information strategies within the context of a single program. We thus provide insights on the relative impact of the traditional (fines and penalties) and emerging (information) enforcement strategies. Our results suggest that British Columbia's list of polluters has a larger impact on both emissions levels and compliance status than orders, fines and penalties traditionally imposed by the

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Ministry and courts. Our results also demonstrate that the adoption of stricter standards and penalties had a significant impact on emissions levels.

Mots Clés : Information, réglementation

Keywords : Regulation, information

1. Introduction

Issues pertaining to the monitoring and enforcement of environmental regulations have surprisingly been the object of only recent and still few empirical analyses.¹ An essential issue of interest is the impact of the various monitoring and enforcement actions on the environmental performance of the plants. Magat and Viscusi (1990), and Laplante and Rilstone (1996) have shown that inspections (or the threat of inspections) significantly reduce absolute levels of water pollution emissions of pulp and paper plants in the United States and Canada respectively. Gray and Deily (1996) have shown that increased enforcement actions in the U.S. steel industry have significantly reduced non-compliance with air pollution emissions standards. Nadeau (1997) has shown that both inspections and enforcement impact the duration of firms' violation of air pollution standards in the pulp and paper industry.²

In view of the difficulties associated with the monitoring and enforcement of environmental standards and regulations, an increasing number of environmental regulators around the world have sought to complement or supplement traditional enforcement actions (fines and penalties) with the adoption of *structured* information programs by which the environmental performance of polluters is revealed.³ Economists have undertaken empirical analyses aimed at measuring the impact of such information programs.⁴ The impact analysed concerns both the reaction of capital markets to the revealed information (Hamilton (1995), Konar and Cohen (1997), Lanoie et al. (1998)), and the changes in the environmental performance of plants as a result of the information release (Konar and Cohen (1997), Afsah et al. (1997)).⁵ While few in numbers, it is generally shown in these papers that capital markets react

¹ For a comprehensive survey of the (modest) empirical literature, see Cohen (1998). Deily and Gray (1991) asserts that their paper is « the first empirical study of the EPA's enforcement activity at the plant level. ».

² If traditional monitoring and enforcement strategies appear to impact the environmental performance of the plants, it then becomes of further interest to understand the determinants of the regulator's allocation of resources devoted to implementation. Empirical analyses on this issue include Deily and Gray (1991), Dion et al. (1998), Helland (1998) and Nadeau (1997).

³ Examples of such programs now abound in both developed (e.g. the Toxics Release Inventory in the United States) and developing countries (e.g. the ECOWATCH program in the Philippines).

⁴ It may be useful to distinguish between *structured* information programs whereby the information release is part of a clearly articulated strategy undertaken by the regulator to reveal the environmental performance of plants from *unstructured* information of the type one finds in newspapers, on a more ad hoc basis.

significantly to both positive and negative environmental news, and that affected firms then markedly improve their environmental performance.

From a policy perspective, a potential weakness of the current body of empirical analyses is their focus on studying either the impact of the traditional monitoring and enforcement practices or the impact of information programs. It is to be noted that none of the above papers combine an empirical analysis of the impact of both traditional enforcement and information strategies within the context of a single research effort. In this paper, we address this weakness and thus hope to provide insights on the *relative* impact of the traditional (fines and penalties) and emerging (information) enforcement strategies.

Since July 1990, the Ministry of Environment, Lands and Parks of British Columbia, Canada (henceforth MOE) publishes a list of firms that either do not comply with the existing regulation or whose environmental performance is of concern to the MOE. Simultaneously however, the Ministry continues to undertake legal action for those violating the regulation. These unique features allow us to analyse the relative contribution of both types of enforcement actions on the performance of polluters. To do so, we focus on the environmental performance of the pulp and paper plants appearing on the list. Our results suggest that British Columbia's list of polluters has a larger impact on both emissions levels and compliance status than penalties traditionally imposed by the MOE and courts. However, the analysis also suggests that the adoption of much stricter environmental standards in 1990 accompanied with a 60 fold increase in the maximum level of penalty explains a large proportion of the reduction in the level of emissions and improvement in compliance status. Our results imply that both regulation *and* information explain the environmental performance of plants.

In the next section, we briefly describe the institutional and regulatory context currently in place in British Columbia, and the model we purport to test. In Section 3, both the estimation strategy and dataset are described. Results are presented in Section 4. We briefly conclude in Section 5.

⁵ Analysis of capital market reactions to *unstructured* information includes Badrinath and Bolster (1996), Dasgupta et al. (1998), Klassen and McLaughlin (1996), Lanoie and Laplante (1994), Muoghalu et al. (1990).

2. Context and model

2.1 Context

Industry and regulatory context

Canada is the largest producer of pulp and paper in the world with approximately 33% of world production. Within Canada, the 23 pulp and paper plants located in British Columbia account for approximately 30% of the Canadian production, with 6.5 million tons of pulp and 1.5 million tons of paper produced in 1992. These amounted to a total production value of approximately 4 billion dollars (CAN),⁶ and 8.5% of British Columbia's GDP.⁷

Pulp is produced essentially with mechanical and/or chemical processes. Mechanical processes are usually more efficient in terms of the required amount of wood input to produce a metric ton of pulp. However, the process produces a fiber of lesser quality than chemical processes. These latter ones are therefore usually preferred. Both sulfite and kraft are chemical pulp production processes. Sulfite processes produce pulp of high quality which needs to be washed, but does not require a bleaching of the pulp. However, sulfite processes involve high production costs mainly because of the impossibility to recover the chemicals used in the process. Kraft processes produce pulp of very high quality. Moreover, kraft offers the possibility of chemical recovery thus making it less expensive to use than sulfite processes. However, kraft processes produce a pulp of a darker color ; this makes it necessary for the pulp to be bleached before being sent to paper machine. The washing and bleaching steps of the production process are important sources of pollution : washing produces large amount of biological oxygen demand (BOD) and total suspended solids (TSS), while bleaching further produces dioxins and furans used to bleach the dark pulp. If the industry is a major contributor to British Columbia's economic activity, it is also one of the most important sources of pollution.

In Canada, jurisdiction over water pollution control (and more generally over pollution control) is shared by the federal and provincial governments. The basis of the overlap relies on the Constitution Act of 1867.⁸ Insofar as water

⁶ In 1992, 1 \$ CAN was approximately worth 0.75 \$ US.

⁷ Province of British Columbia (1993).

⁸ The involvement of the federal government in matters of environmental protection is made possible through its jurisdiction over fisheries, harbours, criminal law, and its residual power to legislate for the peace, order and good government of Canada. The appropriate roles and

pollution is concerned, the Federal government has played an important role through its *Fisheries Act*⁹ under which *Pulp and Paper Effluent Regulations*¹⁰ were first introduced in 1971. However, these Federal regulations were devised in a way that resulted in the bulk of the pulp and paper plants in British Columbia being outside the realm of the regulation, and therefore not having to comply with any of the regulatory standards defined in the *Federal* regulations.

On December 13, 1990 the Government of British Columbia introduces the long-awaited revisions to its own pulp and paper effluent regulations. Each plant must now obtain a discharge permit in order to operate, and the obtention of the permit is conditional on the plant using a secondary wastewater treatment process. Moreover, as shown in Table 1, the revised regulation considerably tightens up the BOD and TSS standards for those plants located on the coast of the province (with the Pacific Ocean).¹¹

Table 1
British Columbia Pulp and Paper Effluent Standards
Pre and Post December 13 1990
(Kg / tone)

		BOD		TSS	
		Kraft process	Mechanical process	Kraft process	Mechanical process
Before Dec. 13, 1990	Coastal plants	30	20	17.5	17.5
	Other plants	7.5	7.5	10	10
After Dec. 13, 1990	All plants	7.5	7.5	11.25	11.25
	Port Alberni	4.2	4.2	3.9	3.9

responsibilities of federal and provincial governments are the subject of an everlasting debate (Kenneth, 1990).

⁹ Revised Statutes of Canada, 1970, c. F-14.

¹⁰ C.R.C. 1978, c. 830.

¹¹ In 1988, the Federal Ministry of Ocean and Fisheries had to put an end to shrimps and crabs fisheries on British Columbia's coastal waters where 3 pulp and paper plants were located. In 1989, oysters fisheries had to be stopped in the vicinity of 6 pulp and paper plants. These events may explain the tightening of the standards for those plants.

While the effluent standards were location specific (coastal vs non-coastal) and process specific (kraft vs mechanical), homogeneous standards were introduced in 1990, with all plants but one having to comply with the same effluent standards, irrespective of their location and production process. Note that the standards were considerably tighter for those plants located on the coastal zone. Standards became effective over a period of 3 years, and all plants had to comply with the new standards by 1994.

Simultaneously with the adoption of the revised regulation, the MOE sought to increase incentives for abatement and compliance with the new set of standards. As a result, the maximum fines for offences under the Waste Management Act increased from 50 000 \$ (CAN) to 3 million \$. At the same time, the MOE declares its commitment to pursue its recently devised strategy to publicize, twice a year, the name of plants falling short of an adequate environmental performance.

British Columbia's list of polluters

On July 13 1990, the MOE of British Columbia released for the first time (in British Columbia and in Canada) a list of industrial operations (and municipalities) which were either not complying with their waste management permits or which were deemed by the Ministry to be a potential pollution concern. The Minister then declared that

the release of this material is a clear indication of our government's intention to deal forthrightly and decisively with pollution concerns. (MOE, Press Release, July 13, 1990)

For each entry, the following information is provided : Name of the firm ; location ; type of concern (e.g. mining operation effluent, pulp mill effluent, sawmill emissions) ; the reason(s) for which the firm is on the list ; and the number of times the firm has been on the list (e.g. second time on noncompliance report ; fourth time on the list).

In order to be listed in the non-compliance section of the list, a firm needs to be *significantly* out of compliance with its permit requirements and standards. Typical entries (reasons) in this section of the list are of the following nature :

- Exceeded permit limits for total suspended solids in July, August, and September ;

- Exceeded permit limits for maximum and average total suspended solids in October, for biological oxygen demand 3 of 13 days in November and for pH two days in December ;
- Exceeded permit limit for opacity for 4 of 6 months ;
- Incomplete submission of monitoring data.

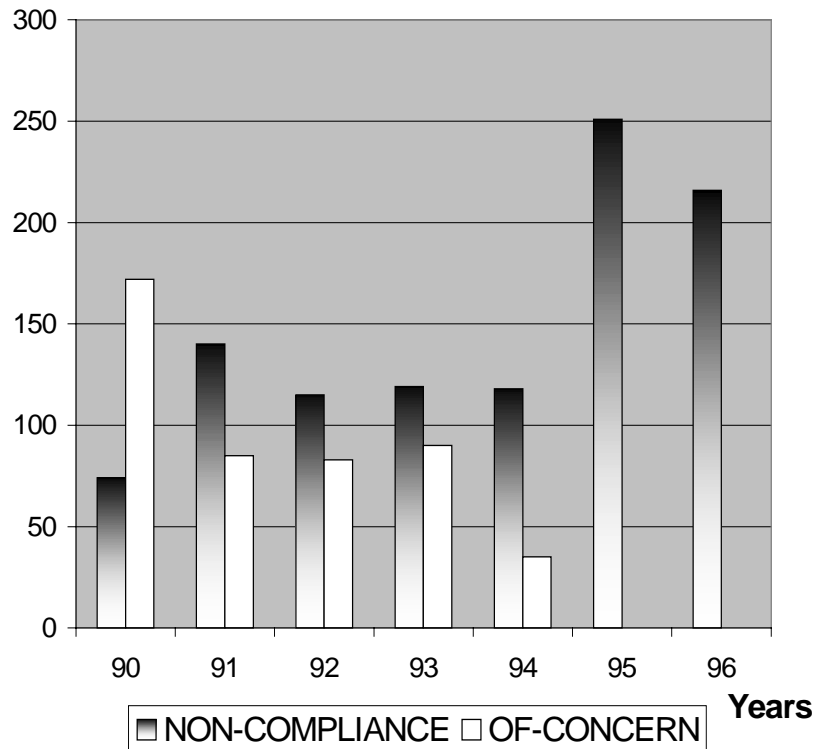
Operations of concern to the Ministry were defined as « operations some of which are technically in compliance and others where permits do not exist or are not required but which by their nature cause concern to the Ministry. » (Press Release, July 13, 1990). Typical entries in this section were of the following nature :

- Concern with possible impact of effluent on Kitimat River, especially at low river flows ;
- Close proximity of landfill leachate to fish bearing streams ;
- Odor problem related to the emission of sulphur gases from the effluent treatment system ;
- Numerous spills and bypasses ;
- Grizzly bears attracted by the disposal of waste at the local landfill.

In 1993, a number of industrial facilities started to express dissatisfaction with appearing on the « pollution concern » section of the list, yet their operations being in compliance with their permit requirements. Moreover, the criteria for being classified as « of concern » were seen as being subjective and inconsistent across regional offices. As a result, this section of the list was dropped in 1994 and as of 1995, British Columbia's list of polluters covers only plants significantly out of compliance with their permit requirements (Figure 1).¹²

¹² MOE (1993).

Figure 1
Total number of citations « Of concern » vs « Out of compliance »
1990-1996



2.2 Model

Following the traditional paradigm for analyzing pollution control issues, the regulator is expected to set and enforce rules of environmental behavior. In keeping with this understanding of the problem, the policy analysis literature has focused on appropriate roles for 'ex ante' regulation (standards vs. market-based instruments) and 'ex post' liability claims by injured parties. This conventional policy discussion has focused almost exclusively on interactions between the regulator and the plant. However, recent research has suggested powerful roles for two additional agents : the community and the market. Indeed, recent evidence throughout the world suggests that neighboring communities can have a powerful influence on plants' environmental performance (Blackman and Bannister, 1998 ; Pargal and

Wheeler, 1996). Communities which are richer, better educated, and more organized find many ways of enforcing environmental norms. Where formal regulators are present, communities use the political process to influence the tightness of enforcement. Where formal regulators are absent or ineffective, 'informal regulation' is implemented through community groups or NGOs.

Moreover, firms operate in local, national and international markets, where many agents can affect revenues and costs. Environmental considerations now affect the decisions of many of these agents. With the worldwide advent of environmental legislation, investors are increasingly scrutinizing environmental performance. Among other factors, they have to weigh the potential for financial losses from regulatory penalties and liability settlements. In recent years, the importance of investor interest has been increased by the growth of new stock markets and the internationalization of investment. For similar reasons, international and local suppliers of financing, industrial equipment, and engineering services are increasingly reluctant to do business with firms known as being large polluters or experiencing problems with environmental regulations. Recent evidence from both the OECD and developing countries suggests that environmental reputation matters for firms whose expected costs or revenues are affected by judgments of environmental performance by customers, suppliers, and stockholders.¹³

Once we introduce a world of multiple agents (and consequently multiple incentives), there may be a need to rethink the regulator's appropriate role in pollution management. It may be that this role is no longer confined to producing, monitoring and enforcing rules and standards. Instead, the regulator can gain leverage through non-traditional programs which harness the power of communities and markets. In this context, there may be ample room for information-oriented approaches such as the public disclosure of plants' environmental performance.

The notion that such a role exists has certainly gained support among environmental policy-makers. Despite this widespread acceptance of a role for the regulator to provide environmental information, the *normative* foundations for a public intervention of that nature have not been formally studied. In particular, the question of whether and under what circumstances environmental information should be publicly provided has not been adequately addressed.¹⁴

¹³ See Cohen (1998) for a thorough review of these studies.

¹⁴ An exception is Kennedy et al. (1994).

From an *empirical* perspective, the impact of existing public disclosure programs on the environmental performance of the plants largely remains to be tested. To our knowledge, only Hamilton (1995) and Konar and Cohen (1997) have proceeded to a formal econometric analysis of this impact ; both of their studies however are based on the U.S. EPA's *Toxics Release Inventory* (TRI). We do not know of any other formal analysis of other public disclosure programs.¹⁵ Moreover, given the characteristics of the TRI program, these authors are unable to account for the impact of the public disclosure strategy *relative* to traditional form of prosecutions, fines, and penalties. In this context, it becomes difficult to determine whether or not information can be an effective regulatory mechanism *relative* to traditional forms of enforcement actions. As pointed out by Konar and Cohen (1997), « before information remedies are used more frequently as regulatory mechanisms, we need to understand how they work and what effect they have on firm behavior ».

Hence, while recent literature appears to indicate a role for public disclosure programs, it is not yet clear whether or not these programs should complement or supplement traditional forms of enforcement. In particular, once the regulator can pursue court actions, fines, and penalties as they typically have done with the enactment of environmental regulations, is there still a role for public disclosure? Can public disclosure create further incentives for pollution control? Given recent research, the model we therefore proceed to test in this paper is of the following nature :

$$\text{Pollution} = f(\text{Regulation, Traditional Enforcement, Public disclosure, } \mathbf{X})$$

where \mathbf{X} is a vector of control variables. In the next section, we proceed to detail our estimation strategy and dataset.

¹⁵ Afsah et al. (1997) provide statistical evidence of the impact of Indonesia's public disclosure program known as PROPER. However, the available information limited them to conduct an *ex ante* – *ex post* analysis. They show that the plants object to the first public disclosure in 1995 reduced their emissions of BOD by approximately 45% within a period of 18 months.

3. Estimation strategy and dataset

For the purpose of our empirical analysis, we use plant-level yearly data from the pulp and paper industry since this industry has a long history of environmental regulation and generally offers the best availability of emissions data.¹⁶

Over the period 1987-1996, 24 pulp and paper plants were in operation in British Columbia. After discussion with the MOE, 4 plants were excluded since their manufacturing processes were hardly comparable with those of the other plants. Five other plants were dropped since MOE's files were incomplete, especially over the period 1987-1990.

Let us turn to the variables used to estimate our model. The definition, mean, and standard deviation of the variables are provided in Table 2. The dataset was entirely provided by the MOE. Most of the data came from public reports. However, data on emissions and limits was provided to us upon special request, and involved a manual investigation of a large number of files.

The analysis is performed for both BOD and TSS. For each of them, we use two different ways of defining the dependent variable, as was used in Laplante and Rilstone (1996) : the absolute level of pollution (ABSBOD, ABSTSS), and a measure of the level of compliance with the emissions standards (COMPBOD, COMPTSS), which is defined as : *(actual emissions – allowable emissions) / allowable emissions*.¹⁷

¹⁶ Magat and Viscusi (1990), Laplante and Rilstone (1996), Dion et al. (1998), Lanoie et al. (1998) also use the pulp and paper industry for a similar reason.

¹⁷ Allowable emissions (kg / day) are calculated as : emissions standards (kg / tonne) times daily production (tonnes / day).

Table 2
Definition, mean and standard deviation of variables
(plant-level yearly data covering 15 plants for the period 1987-1996)

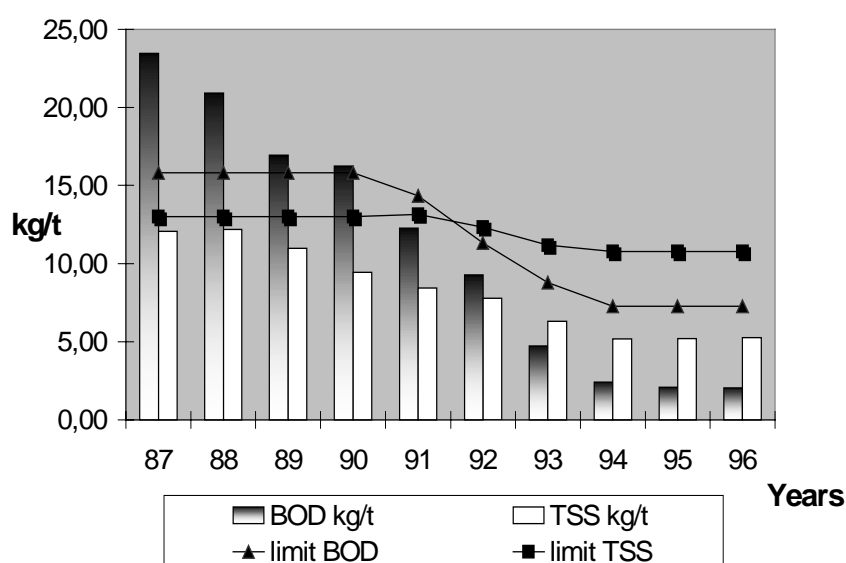
VARIABLES	DEFINITION	MEAN	STANDARD DEVIATION
Dependent variables			
COMPBOD	Compliance rate for BOD (actual – allowable) / allowable	-0.08548	0.3075
COMPTSS	Compliance rate for TSS : (actual – allowable) / allowable	-0.32015	0.37810
ABSBOD	Absolute level of BOD emissions (kg/day)	10479	13187
ABSTSS	Absolute level of TSS emissions (kg/day)	8687.4	6373.6
Independent variables			
OUT OF COMPLIANCE	Number of appearances (in a given year) on the polluters list under the heading «out of compliance»	0.26667	0.53532
OF CONCERN	Number of appearances (in a given year) on the polluters list under the heading «of concern»	0.08889	0.35548
REGUL90	Dummy equal to one when a plant is subject to the new B.C. regulation, 0 otherwise	0.57037	0.49887
PROSECUTION	Number of prosecutions faced by a plant in a given year	0.93333	2.4834
FINE	Total amount of fines imposed on a plant in a given year	4314.1	16529

Table 2 (cont'd)

VARIABLES	DEFINITION	MEAN	STANDARD DEVIATION
Control variables			
PRODUCTION	Production in tons/day	1132.5	510.54
BASSIN	Dummy variables capturing the river in which the plant rejects its effluents		
	Fraser River (omitted)	0.33333	0.47316
	1. Vancouver Bassin	0.26667	0.44386
	2. Howe Sound River	0.13333	0.47316
	3. Columbia Lake	0.06667	0.06268
	4. Skeena River	0.06667	0.06268
	5. Peace River	0.13333	0.11642
REGION	Dummy variable capturing the B.C. administrative region where the plant is located		
	Vancouver Island Region (omitted)	0.26667	0.40386
	1. Lower Mainland Region	0.20000	0.40149
	2. Southern Interior Region	0.06667	0.25037
	3. Cariboo Region	0.06667	0.25037
	4. Skeena Region	0.06667	0.25037
	5. Northern Interior Region	0.26667	0.44386
	6. Kootenay Region	0.06667	0.25037
PROCESS	Dummy equal to 1 if the plant has a mechanical process, 0 otherwise	0.80000	0.40149

Observe in Figure 2 that emissions levels fell considerably over the period of analysis and that compliance rate significantly improved.

Figure 2
Actual emissions and limits



Our independent variables capture the appearance of the plants on the list of polluters, the tightening of the standards in 1990, and the prosecutions and fines imposed on the plants over the period of analysis. As explained previously, until 1994, the lists were divided into two categories : of concern and out of compliance. Accordingly, we have two variables to capture the appearance of the plants on these lists. Since two lists are published every year, and since we are using yearly data, we define the variable OF CONCERN as the number of times a plant has appeared on the lists under this heading in a given year (OUT OF COMPLIANCE is defined the same way). We also lag these variables to allow the plants some time to react to their appearance on the lists¹⁸. In our sample, only one plant never appeared on any

¹⁸ As in Magat and Viscusi (1990) and Lanoie (1992), the use of a lagged policy variable may be justified to avoid any simultaneity problem.

list, while another has appeared only once under the OF CONCERN category. On the contrary, two plants have appeared seven times each on the thirteen lists that were available (six times under the OUT OF COMPLIANCE category).

The variable PROSECUTION is defined as the number of prosecutions against a plant in a given year, while FINE is the total amount of fines imposed on a plant in a given year. These variables are lagged to allow for some time of reaction. From 1987 to 1996, there were 126 prosecutions against the plants in our sample, but only 17 of these resulted in a fine being imposed ; these fines totaled 582 400 \$.

A dummy variable, REGUL90, captures the introduction of the more stringent regulation in 1990. As mentioned earlier, the regulation became effective over the period 1991–1994. Hence, the variable REGUL90 takes the value 1 starting only during the exact year each plant was to operate under the new regulation.

We also include a number of CONTROL VARIABLES. As in Magat and Viscusi (1990) and Laplante and Rilstone (1996), a LAGGED DEPENDENT VARIABLE is introduced to serve as a proxy for the firm's stock of capital related to pollution control and for the general character of its abatement technology. Firms with high levels of pollution in the past are likely to continue to have high levels in the future because the nature of their technology makes it costly to achieve pollution reductions.

We were able to account for the actual level of plants' PRODUCTION through a calculation performed using two sets of pollution limits. Indeed, the MOE produces two series of limits : one expressed in terms of kilograms/tons and another one expressed in terms of kilograms/day. Given that we were provided with the two series, it was easy to calculate a measure of production expressed in terms of tons/day. To our knowledge, this is the first time a measure of the real production is used in a study on pollution levels. Previous authors, such as Magat and Viscusi (1990) and Laplante and Rilstone (1996), used a measure based on plants' production capacity. During the period under study, the average production followed a somewhat erratic path : a sharp increase was observed in the first three years (1987-1990), followed by an important reduction in the 1990-91 recession, then followed by a steady increase until 1996.

Two sets of variables are introduced to capture the localisation of the plants : BASSIN and REGION. BASSIN refers to the river in which each plant rejects its pollutants, while REGION refers to the B.C. administrative region where

the plant is situated. Localisation variables are useful to account for aspects such as varying importance of the ecologist lobby across regions, or potentially different levels of monitoring across regions. These differences may be due, among other things, to the level of deterioration of the local ecosystems (Pargal and Wheeler (1996), Dion et al. (1998)).

Finally, a dummy variable is included to account for the pulp PRODUCTION PROCESS of the mill. Our PROCESS variable is equal to one when the mechanical process is used. Its coefficient is expected to be negative.

4. Empirical results

The estimations are performed using a generalized least-squares (GLS) procedure based on the cross-sectionally and time-wise autoregressive model presented in Kmenta (1986, pp.616-625)¹⁹. Table 3 and 4 present the results pertaining to BOD and TSS respectively. Each table includes eight specifications, four using the compliance rate as the dependent variable and four using the absolute level of pollutant. For each dependent variable, the various specifications allow for different sets of localisation variables, and for lagged or contemporaneous environmental policy variables²⁰. Overall, the explanatory power of the different specifications is satisfactory, and the results are fairly stable across specifications.

The appearance of a plant on the list under the heading OUT OF COMPLIANCE has a contemporaneous impact on both pollutants. Indeed, all coefficients of the variable OUT OF COMPLIANCE, except one, are negative and significant. For BOD, the appearance on the list leads to an improvement of 0.063 in the compliance rate, and to a reduction in the absolute level of emissions in the range of 1111-1164 kg/day. For TSS, the appearance on the list leads to an improvement of the compliance rate of 0.094, and to a reduction in the absolute level of emissions in the range of 1225-1261 kg/day.

¹⁹ Initial tests showed the presence first-order serial correlation and of heteroskedasticity.

²⁰ Other attempts were made using a time trend, fixed effects or the plants' age as additional independent variables. Their inclusion did not improve significantly the explanatory power of our regressions as confirmed by log-likelihood ratio tests.

Table 3: REGRESSION RESULTS – BOD
Coefficients (t-statistics)

	1	2	3	4	5	6	7	8
Dependent variables	COMPBOD	COMPBOD	COMPBOD	COMPBOD	ABSBOD	ABSBOD	ABSBOD	ABSBOD
R SQUARE	0.8947	0.8896	0.9030	0.9002	0.8852	0.8824	0.8841	0.8823
COMPBOD(1) ^b	0.60685 (13.71)*	0.57159 (12.94)*	0.64456 (14.62)*	0.60413 (13.53)*				
ABSBOD(1)					0.65556 (12.97)*	0.64247 (13.17)*	0.66219 (13.04)*	0.64804 (13.27)*
PRODUCTION	-0.67E-04 (-1.179)	-0.89E-04 (-1.59)	-0.79E-04 (-1.477)	-0.11E-03 (-2.094)*	1.1544 (0.292)	1.5326 (1.279)	1.2197 (0.234)	1.6450 (1.434)
PROSECUTION	0.26E-02 (0.2972)	0.35E-02 (0.4021)			63.552 (0.5223)	80.709 (0.6493)		
PROSECUTION(1)			-0.16E-02 (-0.1637)	-0.30E-03 (-0.033)			-68.518 (-0.5573)	-66.051 (-0.5244)
FINE	0.66E-06 (0.4134)	0.78E-06 (0.4725)			-0.31E-01 (-1.78)**	-0.32E-01 (-1.80)**		
FINE(1)			-0.29E-05 (-1.938)*	-0.33E-05 (-2.033)*			-0.25E-01 (-1.560)	-0.25E-01 (-1.494)
REGUL90	-0.17193 (-3.882)*	-0.17191 (-3.774)*	-0.15814 (-3.828)*	-0.16664 (-3.981)	-4310 (-5.045)*	-4511.1 (-5.194)*	-3799.6 (-4.484)*	-4046 (-4.708)*
OF CONCERN	0.53E-02 (0.1215)	0.14E-01 (0.3187)			-1098 (-1.231)	-1059.6 (-1.19)		
OF CONCERN(1)			-0.12E-01 (-0.2727)	-0.39E-01 (-0.8782)			-329.93 (-0.3823)	-250.39 (-0.2893)
OUT OF COMPLIANCE	-0.63E-01 (-1.85)**	-0.48E-01 (-1.318)			-1164.4 (-2.032)*	-1111.4 (-1.91)**		
OUT OF COMPLIANCE(1)			-0.26E-01 (-0.6968)	-0.31E-01 (-0.8509)			-262.08 (-0.3993)	-175.90 (-2684)

PROCESS	-0.14426 (-2.183)*	-0.16612 (-2.229)*	-0.12587 (-1.850)*	-0.14222 (-1.87)**	-1490 (-1.056)	-2389.1 (-1.72)**	-1331.5 (-0.9626)	-2295.7 (-1.69)**
REGION 1	-0.48E-01 (-0.7489)		-0.39E-01 (-0.5940)		-1044 (-0.6878)		-645.30 (-0.4414)	
REGION 2	-0.30E-01 (-0.3371)		-0.36E-01 (-0.4686)		-1657.1 (-0.9010)		-1261.3 (-0.7071)	
REGION 3	-0.28424 (-1.11)		-0.37233 (-1.34)		-2323.7 (-1.141)		-2126.2 (-1.079)	
REGION 4	0.84E-02 (0.60E-01)		-0.97E-02 (-0.1005)		927.22 (0.4213)		679.14 (0.2820)	
REGION 5	0.48E-01 (0.9108)		0.16E-01 (0.2944)		-683.79 (-0.5187)		-482.87 (-0.3810)	
REGION 6	0.65635 (1.410)		0.47485 (0.9113)		473.26 (0.2119)		331.74 (0.1429)	
BASSIN 1		0.27E-01 (0.5328)		0.38E-01 (0.8045)		1799.4 (1.336)		1623.4 (1.238)
BASSIN 2		0.16573 (0.9922)		0.16561 (1.121)		212.56 (0.1913)		384.44 (0.3604)
BASSIN 3		0.78573 (1.659)**		0.63661 (1.193)		1907.4 (0.9609)		1548 (0.7398)
BASSIN 4		0.24E-01 (0.1727)		0.24E-01 (0.2563)		2278.8 (1.134)		1803.8 (0.8050)
BASSIN 5		0.40E-01 (0.4148)		-0.92E-02 (-0.0985)		1852.5 (1.051)		1906.8 (1.143)
CONSTANT	-0.32E-02 (-0.3E-01)	-0.15E-01 (-0.1582)	0.34E-01 (0.3339)	0.34E-01 (0.3939)	4481.3 (1.859)**	3089.8 (1.667)**	3587.8 (1.515)	2438.6 (1.345)
Fischer test	24.41*	24.41*	24.81*	25.71*	23.00*	24.36*	23.29*	24.79*
LIKELIHOOD RATIO TEST	190.93*	188.86*	197.88*	196.03*	93.57*	91.61*	89.98*	87.88*

* significant at 5%, ** significant at 10% ; b (1) means that the variable has been lagged one year

TABLE 4: REGRESSION RESULTS – TSS
Coefficients (t-statistics)

	9	10	11	12	13	14	15	16
Dependent variables	COMPTSS	COMPTSS	COMPTSS	COMPTSS	ABSTSS	ABSTSS	ABSTSS	ABSTSS
R SQUARE	0.9679	0.9194	0.9328	0.9053	0.9477	0.9380	0.9439	0.9358
COMPTSS(1) ^b	0.60324 (11.43)*	0.75797 (14.63)*	0.61274 (9.397)*	0.72925 (11.82)*				
ABSTSS(1)					0.62004 (12.33)*	0.63228 (11.10)*	0.58671 (11.38)*	0.60083 (10.38)*
PRODUCTION	-0.56E-04 (-1.924)**	-0.62E-04 (-1.729)*	-0.50E-04 (-1.473)	-0.57E-04 (-1.499)	2.4796 (3.908)*	1.6780 (2.431)*	2.7832 (4.357)*	2.1067 (3.058)*
PROSECUTION	-0.18E-02 (-0.4848)	-0.26E-02 (-0.4436)			1.2534 (0.0155)	-23.552 (-0.2872)		
PROSECUTION(1)			-0.45E-02 (-0.9946)	-0.37E-02 (-0.6278)			-35.591 (-0.4583)	-62.611 (-0.7571)
FINE	0.16E-05 (1.553)	0.21E-05 (1.877)**			0.52E-02 (0.4768)	0.24E-02 (0.2018)		
FINE(1)			-0.93E-06 (-1.393)	-0.84E-06 (-0.9770)			-0.14E-03 (-0.014)	0.58E-03 (0.0508)
REGUL90	-0.70E-01 (-2.503)*	-0.23E-01 (-0.8591)	-0.69E-01 (-2.392)*	-0.41E-01 (-1.263)	-1492.1 (-3.699)*	-1291.4 (-3.139)*	-1909.6 (-4.628)*	-1745.2 (-4.165)*
OF CONCERN	-0.48E-01 (-2.296)*	-0.69E-01 (-1.95)**			-33.697 (-0.087)	43.531 (0.1020)		
OF CONCERN(1)			-0.26E-01 (-0.7079)	-0.32E-01 (-0.7600)			-346.53 (-0.9288)	-325.81 (-0.8024)
OUT OF COMPLIANCE	-0.93E-01 (-3.914)*	-0.95E-01 (-3.123)*			-1261.2 (-3.588)*	-1225.1 (3.413)*		
OUT OF COMPLIANCE(1)			-0.38E-01 (-1.367)	-0.45E-01 (-1.381)			-495.98 (-1.203)	-482.26 (-1.139)

PROCESS	-0.11142 (-2.046)*	-0.95E-02 (-0.1842)	-0.10756 (-1.91)**	-0.24E-01 (-0.4512)	-750.81 (-1.458)	-105.85 (-0.1912)	-654.28 (-1.298)	-118.17 (-0.2224)
REGION 1	-0.44E-01 (-1.556)		-0.56E-01 (-1.49)		-1235.5 (-2.010)*		-1245.9 (-2.007)*	
REGION 2	0.27E-01 (0.3049)		0.24E-01 (0.2663)		213.19 (0.1541)		221.20 (0.1564)	
REGION 3	0.27979 (3.113)*		0.26113 (2.810)*		2149 (2.576)*		1939.8 (2.279)*	
REGION 4	0.18074 (2.26)*		0.16197 (1.722)**		2358.7 (2.555)*		2179.9 (2.116)*	
REGION 5	0.10851 (2.502)*		0.11354 (3.072)*		1162.5 (2.286)*		1005.7 (1.978)*	
REGION 6	0.10432 (1.142)		0.67E-01 (0.6274)		964.13 (1.133)		649.89 (0.7328)	
BASSIN 1		-0.16E-01 (-0.4686)		-0.66E-01 (-1.84)**		-1131 (-1.947)*		-1036.2 (-1.771)*
BASSIN 2		-0.11893 (-1.69)**		-0.95E-01 (-1.28)		-1609.6 (-1.94)**		-1616.3 (-1.987)*
BASSIN 3		0.43E-02 (0.052)		-0.56E-01 (-0.5679)		-240.43 (-0.2720)		-382.15 (-0.4152)
BASSIN 4		0.94E-01 (1.252)		0.50E-01 (0.5698)		1417.6 (1.557)		1323.9 (1.281)
BASSIN 5		-0.23E-01 (-0.4112)		-0.53E-01 (-0.9011)		-890.29 (-1.16)		-762.13 (-0.9610)
CONSTANT	-0.87E-01 (-1.423)	-0.53E-02 (-0.053)	-0.92E-01 (-1.358)	0.23E-01 (0.3884)	-1492.1 (-3.699)*	2216.7 (2.062)*	867.84 (1.038)	2157.7 (1.993)*
FISCHERTEST	48.41*	30.60*	32.52*	24.42*	37.50*	35.45*	31.77*	31.11*
LIKELIHOOD RATIO TEST	65.80*	50.96*	67.93*	54.13*	86.15*	83.36*	75.72*	73.93*

* significant at 5%, ** significant at 10% ; b (1) means that the variable has been lagged one year

The significance of the contemporaneous OUT OF COMPLIANCE variable and not of the lagged variable is not necessarily surprising given that there are generally two lists a year (in certain years, the first list was published in January). The appearance on the list under the heading OF CONCERN seems to have no impact on pollution, which may suggest that the MOE may have been correct to eliminate this category in 1994.

The variable capturing the major change in regulation REGUL90 is almost everywhere negative and significant. The impact of this new regulation is strong : improvement in the compliance rate of 0.158 for BOD and of 0.07 for TSS ; reduction of the level of emissions in the range of 3800-4511 kg/day for BOD and in the range of 1291–1909 kg/day for TSS.

As discussed earlier, such a change in limits leads to an increase the expected probability of being caught in non-compliance with the negative consequences that may follow for firms. Plants' reactions to the new limits have been important ; as shown in Figure 2, plants had a better rate of compliance at the end of the period with stricter limits than at the beginning of the period when limits were less stringent. Discussions with MOE officials led us to believe that, with the new limits, all firms had to be equipped with « state-of-the-art » abatement technologies (secondary treatment), which have been installed in only few recent plants before the new regulation was adopted.

PROSECUTIONS have no impact on either types of pollutants, while lagged FINES lead to an improvement in the BOD compliance rate (elasticity in the -0.15 / -0.17 range). It is instructive to compare the magnitude of the impact of fines versus appearing as being « out of compliance ». Can it be said whether the « information approach » has a greater or a smaller impact than the traditional enforcement mechanisms? It is difficult to compare the coefficients of these variables given that the FINE variable is continuous and can be interpreted through the calculation of a conventional elasticity, while the OUT OF COMPLIANCE variable is a non-continuous dummy variable. Nevertheless, three observations can be made.

First, the appearance on the out of compliance list has an impact on both types of pollutants (expressed either in absolute terms or in terms of compliance rate), while the fines only have an effect on the BOD compliance rate (and not on absolute emissions levels). Second, our coefficients indicate that doubling the average size of the fines would lead to an improvement in the BOD compliance rate of approximately 15 %, i.e. a reduction of 0.013 in the compliance rate ; on the other hand, an additional appearance on the OUT OF COMPLIANCE list leads to a reduction of 0.063 in the BOD compliance rate.

Third, the fact that lagged FINES variable is significant, while it is the contemporaneous OUT OF COMPLIANCE variable that is significant, may suggest that lists of worst polluters can provide a stronger incentive than conventional enforcement measures for a quick response to correct a damageable situation. Altogether, these three observations suggest that the B.C. lists could have had a stronger impact than the fines as they were applied.

Among the CONTROL VARIABLES, the lagged dependent variable has everywhere a strong and significant impact. The coefficients are in the 0.57-0.75 range, which implies that approximately 65% of the pollution in a given year (absolute emissions or compliance rate) is explained by the pollution in the preceding year. Similar results were observed elsewhere (Magat and Viscusi (1990) have coefficients in the 0.95-0.98 range).

The PRODUCTION level has a positive impact on the absolute level of TSS emissions and a negative impact on the TSS compliance rate (elasticity in the range 0.22 / 0.36 for the absolute level of pollution, and in the range -0.21 / -0.26 for the compliance rate). These results suggest that larger firms may be able to comply more easily with the regulation for reasons like the existence of economies of scale in the abatement technology. For BOD, the same pattern is observed in the signs of the coefficients, but only one of them is significant. This result parallels that of Lanoie et al. (1998) showing that reductions in production may be a good mean to reduce TSS emissions, but not necessarily a good way to influence BOD emissions.

The LOCALISATION variables are never significant, except one, in the regressions related to BOD, while many of them are significant in the regressions related to TSS. This indicates that, for TSS, specific characteristics of the localisation, like stringency of local DOE officials, have an influence. Lastly, the coefficients of our PROCESS variable are everywhere negative, and they tend to be more significant in the BOD regressions than in the TSS. This shows that, as expected, the use of the mechanical process leads to higher compliance rate and lower absolute levels of emissions.

5. Conclusion

This paper has examined the relative impact of both traditional enforcement practices and information strategies on pollution levels and rates of compliance. The analysis was performed in the context of British Columbia where the MOE publishes, since 1990, a list of firms that either do not comply with the existing regulation or that are of concern to the MOE, and where simultaneously the Ministry continues to undertake legal action for those violating the regulation. The empirical investigation was based on a sample covering 15 plants in the B.C. pulp and paper industry during the period 1987 – 1996, and two types of pollutants were considered : BOD and TSS. Our results showed that (1) a tightening up of the standards in 1990 had a very significant impact on plants' environmental performance ; (2) appearances on polluters' list under the heading « out of compliance » led plants to improve their environmental performance ; and (3) fines had a beneficial impact on plants' compliance rates with respect to BOD. Furthermore, we provided some evidence that the impact of appearing on the polluters' list was stronger than that of fines.

Our analysis suggests that, although useful, information strategies cannot necessarily replace traditional enforcement practices in the area of environmental protection. In fact, these two approaches can perhaps better be used as complementary policy instruments in order to achieve improvements in firms' environmental performance. This way of proceeding presents the advantage of putting different types of pressure (reputational, financial, judiciary) on firms, increasing the likelihood that they will undertake actions in line with environmental protection.

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